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Research on the Impact of the "Dual Pilot" Policy on Corporate Green Technological Innovation: A Quasi-Natural Experiment Based on Low-Carbon City Pilots and Intellectual Property Demonstration Initiatives

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Abstract

Amid dual pressures from internal and external economic and environmental factors, stimulating corporate green technological innovation is pivotal to achieving carbon peaking and carbon neutrality goals while advancing industrial upgrading. Existing research predominantly examines the impact of individual policies on corporate green innovation, with limited attention to policy synergies. Using Shanghai and Shenzhen A-share listed companies from 2007 to 2022 as the research sample, this study treats the intellectual property demonstration city and low-carbon city pilot policies as quasi-natural experiments. Employing a progressive difference-in-differences model, it systematically examines the impact and mechanism of dual pilot policy synergies on corporate green technological innovation. Findings reveal that the synergistic dual pilot policies significantly enhance corporate green technological innovation levels, with a more pronounced effect on substantive green innovation. The primary pathways of this effect involve strengthening executives' environmental and innovation awareness, increasing corporate R&D intensity, and improving regional legal environments. Policy effects exhibit significant heterogeneity, with more pronounced positive impacts on high-profile enterprises without environmental backgrounds, as well as firms in highly competitive industries and economically developed regions. Overlaying the IP demonstration city pilot on the low-carbon city pilot more effectively stimulates corporate green innovation vitality. These findings provide crucial empirical evidence and policy references for deepening the synergy between intellectual property protection and environmental regulation policies, thereby precisely advancing corporate green technological innovation.

Keywords

Intellectual Property Demonstration City, Low-Carbon City, Policy Synergy, Corporate Green Technological Innovation.

1. Introduction

The world today faces persistent geopolitical turbulence, with the global economic recovery hindered by the spread and escalation of protectionist and unilateralist tendencies, compounded by intertwined risks and challenges. Domestically, pressure from slowing economic growth is becoming more pronounced, environmental governance demands are significant, and the task of optimizing and upgrading the energy consumption structure is increasingly urgent, necessitating the exploration of new engines for economic growth. Internationally, the external environment is growing increasingly complex and severe, with

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core technological sectors facing blockades and restrictions from developed nations, creating bottlenecks that require urgent breakthroughs. Under these dual pressures, placing innovation at the core of development, prioritizing the cultivation of green emerging technologies centered on new energy, and fully activating the vitality of enterprises as the main drivers of innovation are not only essential for China to practice sustainable development and achieve its dual carbon goals, but also crucial for breaking through technological monopolies imposed by developed countries and advancing industrial restructuring and upgrading.[0]

In this process, enterprises serve as the primary drivers of innovation, and their capacity for green technological innovation directly impacts the achievement of the dual carbon goals. However, green technological innovation is characterized by high investment, high risk, and long return cycles. It also faces the “dual externalities” problem—positive externalities from technology spillovers and negative externalities from pollution emissions—which severely dampens enterprises' motivation to innovate. To encourage enterprises to proactively engage in green technological innovation, environmental regulatory policies must play a guiding role in fostering a green social ethos and expanding green market demand. Concurrently, a robust intellectual property system is essential to provide solid safeguards.

Literature closely related to this paper primarily unfolds on two levels. On one hand, perspectives on the relationship between intellectual property protection and green technological innovation vary among domestic and international scholars. From the institutional effectiveness dimension, relevant studies have demonstrated through model simulations that intellectual property protection can strengthen institutional constraints at the enforcement and legislative levels, thereby advancing corporate green technological innovation. This effect is particularly pronounced in regions with heightened ecological and environmental awareness; Extending to the urban spatial perspective, intellectual property protection exhibits spatial spillover effects, not only significantly enhancing the green technology innovation level of the host city but also positively influencing surrounding cities; Empirical analyses based on micro-enterprise data reveal that intellectual property protection can facilitate corporate green technology innovation by driving increased R&D investment and attracting foreign capital inflows. This promotional effect is more pronounced in enterprises operating in highly monopolized markets[1]; Further research categorizes corporate green technology innovation into product innovation and process innovation. Structural equation modeling confirms that intellectual property protection and government support jointly drive corporate participation in open innovation, green process innovation, and green product innovation, with open innovation serving as a moderator in this mechanism[5]; Incorporating R&D modes into the analytical framework reveals that distinct strategies—independent R&D versus collaborative R&D—yield differentiated effects on promoting various types of green technology innovation [6].

On the other hand, regarding the relationship between environmental regulations and corporate green technological innovation, three representative academic perspectives have emerged: First, the traditional view holds that environmental regulations directly increase corporate costs, thereby suppressing green technological innovation activities[7], This is typically manifested in the early stages of policy implementation, where rising pollution control costs squeeze R&D funding and weaken innovation incentives[8]; Second, proponents of the Porter Hypothesis argue that appropriate environmental regulations can trigger a “compensation for innovation” effect, enabling enterprises to enhance both production efficiency and market competitiveness through technological innovation[9], Related studies further reveal that the synergistic effect of green finance and environmental regulations can significantly promote corporate green technological innovation, particularly in the output of green invention patents and new energy-related green patents; Third, another perspective contends that the relationship between the two is not simply linear. Moderate environmental

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regulations can activate corporate innovation potential by raising environmental standards, driving technological upgrades and industrial transformation. However, overly stringent regulations may suppress innovation due to excessive increases in corporate costs.

In summary, although academia has conducted extensive research on the impact of intellectual property protection and environmental regulations on corporate green technological innovation, existing studies predominantly focus on the independent effects of individual pilot policies, rarely analyzing them from a policy synergy perspective. Examining the impact of intellectual property protection or environmental regulation in isolation often fails to fully reveal the complex evolutionary logic of corporate green technological innovation. Therefore, this paper integrates the intellectual property demonstration city and low-carbon city pilot policies into a quasi-natural experiment. Drawing on microdata from Shanghai and Shenzhen A-share listed companies from 2007 to 2023, it delves into the effects of corporate green technological innovation under the synergistic influence of intellectual property protection and environmental regulation.

2. Theoretical Analysis and Research Hypotheses

2.1. Direct Effects

Compared to single-policy pilot regions, the synergistic implementation of dual pilot policies—intellectual property demonstration cities and low-carbon cities—demonstrates stronger green innovation-driving capabilities. On one hand, the dual policies create dual incentives: intellectual property protection provides legal safeguards and revenue certainty for corporate green technological innovation, while low-carbon city policies compel enterprises to enhance energy efficiency, advance production emission reductions, and pursue low-carbon industrial transformation, collectively boosting corporate initiative in green R&D. On the other hand, their synergy reduces technology transfer risks, promotes collaborative R&D, and integrates policy resources to optimize the innovation environment, accelerating the diffusion and application of green technologies. Based on this, we propose:

H1: The synergistic implementation of dual pilot policies—IP protection and environmental regulation—significantly promotes corporate green technological innovation.

2.2. Mediating Effect of Executives' Environmental Awareness

The synergistic dual pilot policies can transmit green innovation momentum by strengthening executives' environmental awareness and innovation cognition. Under the intellectual property protection framework, executives gain clarity on the legal safeguards for innovation outcomes, bolstering their confidence in R&D investment. This leads them to proactively seek green environmental information and heighten their environmental awareness. Meanwhile, low-carbon city policies increase pollution costs and set environmental standards, compelling executives to prioritize green technology R&D to ensure corporate compliance and competitiveness. Executive environmental and innovation cognition serves as a critical prerequisite for corporate green innovation. It enables enterprises to keenly identify green market opportunities, integrate internal and external resources, foster environmental corporate culture, and drive deep green innovation transformation. Therefore, we propose:

H2 : Dual pilot policy coordination indirectly promotes corporate green technological innovation by enhancing executive environmental and innovation cognition.

2.3. Mediating Effects of Corporate R&D Investment

The dual pilot policy synergy can amplify the mediating role of R&D investment to advance green technological innovation. From a policy transmission perspective, intellectual property protection reduces innovation risks and enhances trust in technology transactions by

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improving legislative and judicial safeguards, thereby stimulating corporate innovation enthusiasm. Low-carbon city policies, meanwhile, lower green R&D costs through fiscal incentives and tax breaks while increasing the opportunity cost of non-green production via carbon emission constraints, creating dual pressure for enterprises to increase green technology R&D investment. From an input perspective, high R&D expenditure not only provides financial support for corporate green innovation and alleviates compliance cost pressures but also drives collaborative innovation across the industrial chain, accelerating full-chain green transformation and green product iteration. Based on this, we propose:

H3: The synergistic dual pilot policies indirectly promote corporate green technological innovation by increasing the intensity of corporate R&D investment.

2.4. The Mediating Effect of Regional Legal Environment

The synergistic dual pilot policies can empower corporate green innovation by optimizing the regional legal environment. Strengthening intellectual property protection not only safeguards innovation returns for enterprises and attracts both local and foreign innovation talent, but also fosters a social culture that respects innovation, providing cultural support for innovative activities. Simultaneously, a sound legal environment helps establish a fair competitive market system, prevents the “bad money drives out good money” phenomenon, promotes the dissemination of green technologies and supply chain coordination, and provides a stable institutional environment for corporate green innovation. A sound legal environment effectively incentivizes enterprises to increase green technology R&D and application, fostering a win-win outcome for both economic growth and environmental sustainability. Based on this, we propose:

H4 : The synergistic dual pilot policy indirectly promotes corporate green technological innovation by improving the regional legal environment.

3. Study Design

3.1. Double Difference Model

To examine the impact of the dual pilot policy—combining intellectual property demonstration cities with low-carbon cities—on enterprises' green innovation capabilities, this study employs an incremental double difference model with the following specifications:

$$Gp_{it} = \alpha + \beta did_{it} + \gamma X_{it} + u_i + \lambda_t + \varepsilon_{it}$$

$$did_{it} = treat_i \times post_t$$

Among these, Gp_{it} represents the dependent variable, measured by two indicators: the number of green invention patents granted to enterprises (Gip_{it}) and the number of green utility model patents granted (Gup_{it}). did_{it} serves as the core explanatory variable, denoting the dummy interaction term for the “dual pilot” policy. X_{it} functions as a control variable, encompassing other factors potentially influencing corporate green technological innovation. u_i and λ_t respectively control for individual fixed effects and time fixed effects, while ε_{it} acts as the random disturbance term.

3.2. Variable Explanation

(1) The dependent variable is corporate green technological innovation. Existing research predominantly employs green patent output metrics to measure this variable, with green patent applications being a commonly used proxy variable. While application volume reflects the level of corporate green innovation activity, it cannot directly indicate innovation quality or success rates. Relying solely on application volume may overestimate the actual effectiveness

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of corporate green innovation. In contrast, the number of green patent grants signifies that the relevant technology has passed the substantive examination by the patent office, demonstrating practical application value and market potential. This metric more accurately reflects a firm's genuine innovation capabilities and output in the field of green technology. This paper adopts the measurement approach from Qi Shaozhou (2018) and Wang Yonggui et al. (2023), distinguishing green technological innovation into substantive green innovation and strategic green innovation. These are measured by the number of authorized green invention patents (Gip_{it}) and authorized green utility model patents (Gup_{it}), respectively. Considering the prevalence of zeros in green patent data, this study applies a transformation by adding 1 to the raw patent counts and then taking the logarithm to eliminate heteroskedasticity effects.

(2) Core Explanatory Variable: The dummy variable for the “dual pilot” policy of intellectual property demonstration cities and low-carbon cities (did_{it}) is essentially an interaction term between the city dummy variable ($treat_i$) and the time dummy variable ($post_t$). Within the study period, 30 cities were simultaneously included in both policy pilot programs: the city dummy variable takes a value of 1 when the enterprise's registered city $treat_i$ is selected for both the intellectual property demonstration city and low-carbon city pilot programs, and 0 otherwise. For treatment group enterprises, the time dummy variable $post_t$ takes a value of 1 in the year the dual pilot policy was implemented and subsequent years, and 0 otherwise.

Table 1: List of Pilot Cities

Year	Dual-Pilot Cities
2012	Shenzhen, Hangzhou, Wuhan, Guangzhou, Suzhou, Zhenjiang, Wenzhou, Qingdao
2013	Xiamen, Ningbo, Guiyang
2015	Nanchang
2017	Dalian, Nanjing, Changzhou, Jiaxing, Hefei, Jinan, Yantai, Weifang, Changsha, Zhuzhou, Xiangtan, Zhongshan, Chengdu, Changji
2018	Shijiazhuang, Shenyang
2019	Kunming, Jinhua

(3)Control Variables: Drawing upon existing literature designs, this study selects the following control variables at the firm level to eliminate interference from other heterogeneity factors on the core relationship: Firm Size (Size): Represented by the natural logarithm of year-end total assets, controlling for the impact of firm size differences on innovation investment; Debt-to-Asset Ratio (Lev): Reflecting debt repayment pressure through the ratio of year-end total liabilities to total assets, measuring financial leverage levels; Return on Equity (ROE): Measuring corporate profitability efficiency via the ratio of net profit to average total assets, reflecting the supportive role of profitability in innovation; Fixed Asset Ratio (Fixed): Reflecting corporate asset structure characteristics through the ratio of net fixed assets to total assets, controlling for the impact of capital-intensive attributes; Tobin's Q Ratio (TobinQ): Calculated as (Market Value of Floating Shares + Non-Traded Shares × Book Value per Share + Book Value of Liabilities) / Total Assets, reflecting the relative relationship between market value and asset replacement cost; Growth Potential (Growth): Represented by revenue growth rate, controlling for the impact of development stage on innovation decisions; Firm Age: Calculated as ln(Current Year − Year of Establishment + 1) to control for differences in the firm's life cycle; Ownership Structure (SOE): A dummy variable valued at 1 for state-controlled enterprises and 0 otherwise, distinguishing the impact of property rights on innovation resource allocation; Top 10 Shareholder Ownership Ratio (Top10): Reflects equity concentration through the proportion of shares held by the top 10 shareholders relative to total shares, controlling for the role of governance structures in innovation.

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3.3. Data Sources and Descriptive Statistics

This study selects Shanghai and Shenzhen A-share listed companies from 2007 to 2022 as the research sample. Data sources are as follows: Enterprise green patent data was obtained from the China National Research Data (CNRDS) platform. Financial indicator data came from the China Securities Market Research (CSMAR) database. Intellectual property adjudication data was sourced from the Peking University Legal Database. To enhance sample quality, the original data underwent multidimensional screening and processing: (1) Financial sector companies were excluded due to their distinct business models and financial structures, which differ significantly from non-financial industries; (2) Listed companies subject to ST, *ST, or PT delisting warnings were excluded to eliminate interference from financially abnormal samples; (3) Samples with severe data missingness were directly discarded, while minor missing observations were supplemented using linear interpolation; (4) Finally, to mitigate the impact of extreme values on regression results, all continuous variables underwent two-tailed trimming at the 1% level.

Table 2: Descriptive Statistics

	mean	sd	min	max	count
gip	0.5567	0.9025	0.0000	3.9890	35320
gup	0.4756	0.8293	0.0000	3.7136	35320
did	0.2353	0.4242	0.0000	1.0000	35320
Size	22.1467	1.2747	19.7432	26.1532	35320
Lev	0.4412	0.2039	0.0510	0.9027	35320
ROE	0.0597	0.1429	-0.7026	0.3993	35320
FIXED	0.2215	0.1632	0.0020	0.6987	35320
TobinQ	2.0587	1.3179	0.8538	8.5108	35320
Growth	0.1700	0.4246	-0.5971	2.7045	35320
FirmAge	2.8674	0.3582	1.6094	3.5264	35320
SOE	0.4059	0.4911	0.0000	1.0000	35320
TOP10	57.0037	15.1899	22.6454	90.3881	35320

4. Empirical Findings and Analysis

4.1. Baseline Regression

To examine the direct impact of the dual pilot policy on intellectual property protection and environmental regulation on corporate green technological innovation, this study employs an incremental difference-in-differences model with dual fixed effects for empirical testing. The baseline regression results are presented in Table 3. Column (1) and (3) report regression results controlling only for individual and time fixed effects, while Column (2) and (4) present estimates after further incorporating firm-level control variables. Across all regression results, the coefficients of the core explanatory variables are statistically significant at the 1% level. This indicates that the coordinated implementation of intellectual property protection and environmental regulation policies significantly promotes corporate green technological innovation, providing empirical support for research hypothesis H1.

Table 3: Baseline regression results

	Gip		Gup	
	(1)	(2)	(3)	(4)
did	0.0789***	0.0760***	0.0609**	0.0583**
	(0.0263)	(0.0247)	(0.0248)	(0.0234)

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Size		0.2672***		0.2387***
		(0.0169)		(0.0159)
Lev		-0.0860*		-0.0673
		(0.0521)		(0.0501)
ROE		-0.0204		0.0059
		(0.0358)		(0.0345)
FIXED		0.3078***		0.2857***
		(0.0705)		(0.0664)
TobinQ		0.0102**		0.0088**
		(0.0047)		(0.0044)
Growth		-0.0250***		-0.0193**
		(0.0081)		(0.0080)
FirmAge		0.1875*		0.1502*
		(0.0956)		(0.0903)
SOE		0.0327		0.0416
		(0.0329)		(0.0302)
TOP10		0.0004		0.0007
		(0.0007)		(0.0007)
Constant	0.5382***	-5.9984***	0.4613***	-5.3624***
	(0.0062)	(0.4249)	(0.0058)	(0.4045)
R2	0.626	0.643	0.591	0.607
Count	35,320	35,320	35,320	35,320

Note：Standard errors in parentheses， * p < 0.1, ** p < 0.05, *** p < 0.01

4.2. Parallel Trends Test

The validity of the difference-in-differences model hinges on the parallel trends assumption, which requires that the treatment and control groups exhibit common trends prior to policy intervention. This study employs event analysis to examine the dynamic effects of dual pilot policies on corporate green technological innovation, thereby testing this assumption. The model specification is as follows.。

$$Gp_{it} = \alpha + \sum_{k \geq -10, k \neq -1}^{10} \mu_k D_{it}^k + \gamma X_{it} + u_i + \lambda_t + \varepsilon_{it}$$

This study constructs a dynamic dummy interaction term D_{it}^k to replace the core explanatory variable did_{it} in the baseline regression, enabling testing of the dynamic policy effects. Here, D_{it}^k represents the interaction term between the dummy variable for year k (before or after policy implementation) and the policy variable, while μ_k denotes the regression coefficient relative to the base year. Other variables are set consistent with the baseline model. Considering that the overlapping years of the intellectual property demonstration city and low-carbon city pilot policies primarily occurred in 2012 and 2017, this study sets the event study window to 10 years before and after policy implementation. The sample from the year prior to policy implementation is excluded to avoid multicollinearity interference.

The test results in Figure 1 indicate that prior to policy implementation, no significant difference existed between the treatment group and control group in terms of corporate green technological innovation levels. Following policy rollout, the synergistic dual pilot policy gradually unleashed its positive driving effect on corporate green technological innovation.

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This policy effect exhibits a certain degree of lag, stemming from the time required for macro policies to transition from formulation to implementation and generate tangible impacts, while micro-level firms also need time to adapt their production decisions and technological adjustments to policy changes. The above results confirm that prior to the dual pilot policy implementation, the treatment and control groups satisfied the parallel trends assumption, thereby validating the prerequisite conditions for the difference-in-differences model.

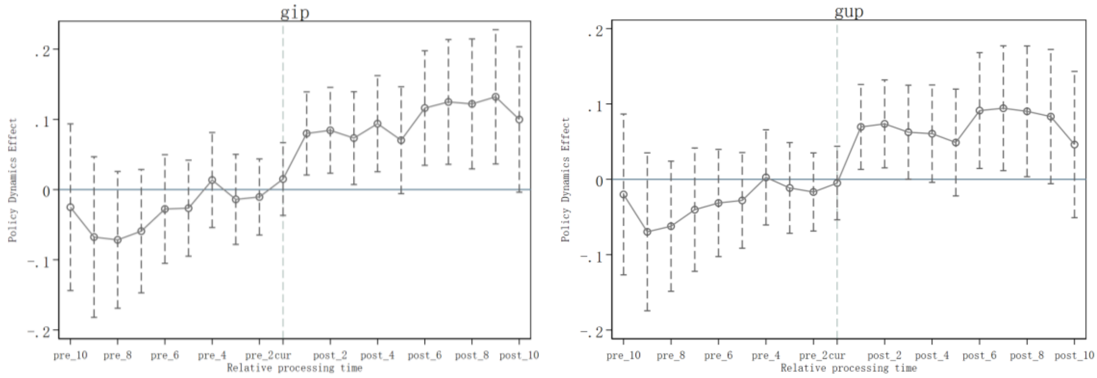

Figure 1: Parallel Trend Test Results

4.3. Placebo Test

To further exclude the interference of unobservable omitted variables on estimation results, this paper employs a placebo test to validate the robustness of the benchmark regression results: 500 random samples are drawn from the dataset to construct a dummy treatment group, which is then substituted into the benchmark regression model for re-estimation. As shown in Figure 2, the estimated coefficients of core explanatory variables exhibit a normal distribution centered around zero after randomization. This indicates that the dual pilot policy's promotion of corporate green innovation is not driven by unobservable factors. The test results support the reliability of the benchmark regression conclusions.

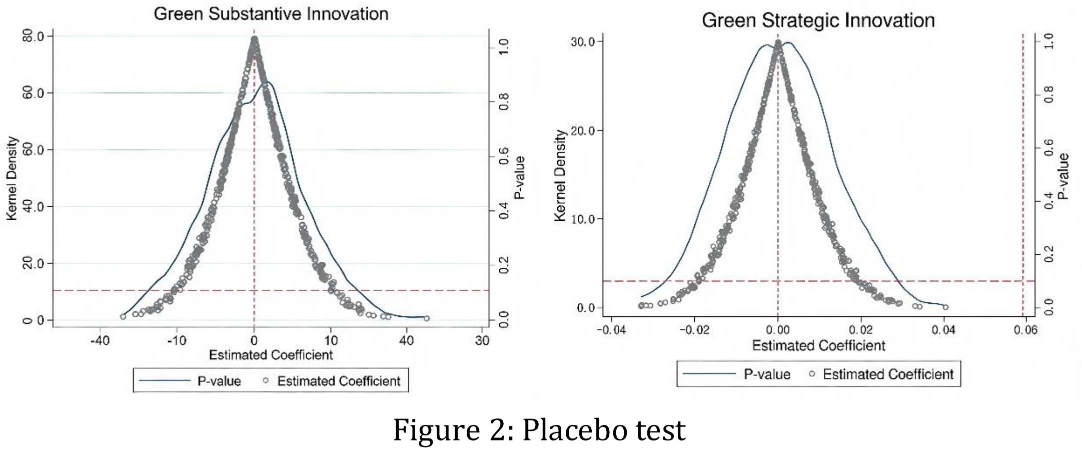

Figure 2: Placebo test

4.4. Robustness Tests

4.4.1. Substituting Dependent Variables

To comprehensively measure corporate green innovation capabilities, this study employs the number of green invention patent applications and green utility model patent applications as alternative dependent variables. These metrics reflect corporate innovation activities from different dimensions compared to the patent grant count used in the baseline regression: patent application volume emphasizes the initial momentum and frequency of innovation, while patent grant count focuses on the success rate and quality level of innovation outcomes. As shown in Table 4 (1)-(2), the coefficients for core policy variables remain significantly positive, indicating that the dual pilot policy's promotional effect on corporate green innovation is stable and unaffected by differences in dependent variable measurement methods.

4.4.2. Adjusting Sample Structure

Considering the potential for systematic bias in regression results due to the unique administrative levels, economic development, and geographical locations of municipalities directly under the central government and autonomous regions, this study re-ran the regression after excluding sample data from 4 municipalities and 5 autonomous regions. Columns (3) and (4) of Table 4 show that the adjusted regression results remain consistent with the baseline model. The significance and direction of the core policy variable coefficient show no substantive changes, confirming the robustness of the baseline conclusions across different sample structures.

4.4.3. Changing the Estimation Model

Compared to traditional two-way fixed-effects models, dual machine learning models impose no restrictions on parameter forms and can incorporate more control variables to improve model fit, yielding more robust results. This study employs this model to estimate the policy effects of the dual pilot program, dividing the dataset into a 1:4 training-to-prediction ratio and solving via the random forest algorithm. Columns (5) and (6) in Table 4 show that the coefficient for the policy dummy variable remains significantly positive, further corroborating the robustness of the findings.

Table 4: Robustness Test Results

	Replace the dependent variable		Adjust the sample structure		Replace the estimation model	
	(1)	(2)	(3)	(4)	(5)	(6)
	Gip	Gup	Gip	Gup	Gip	Gup
did	0.0266*	0.0249*	0.0775***	0.0569*	0.1625***	0.1342***
	(0.0157)	(0.0138)	(0.0252)	(0.0239)	(0.0121)	(0.0102)
cons	-0.8333***	-0.5798***	-5.9947***	-5.4074***	0.0931***	0.0832***
	(0.2332)	(0.2094)	(0.4725)	(0.4522)	(0.0034)	(0.0031)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Sample	35320	35320	26,687	26,687	35320	35320
R2	0.617	0.578	0.612	0.574		

5. Mechanism Verification

Previous research has confirmed that the dual pilot policy significantly enhances corporate green technological innovation levels through synergistic effects. However, its transmission mechanism remains to be clarified: through which key pathways does the policy influence corporate green innovation behavior? This paper constructs the following mediation effect model:

$$Shift_{it} = \alpha + \beta did_{it} + \gamma X_{it} + u_i + \lambda_t + \varepsilon_{it}$$

Where $Shift_{it}$ represents the mediating variables, specifically comprising corporate executive perceptions, R&D intensity, and regional intellectual property protection levels. The remaining variables are set consistent with the baseline regression.

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5.1. Executive Cognitive Drivers

Executive environmental awareness reflects their commitment to green development, while innovation cognition directly influences corporate innovation decisions (e.g., investment direction, resource allocation). Under strengthened property rights protection and green development policies, executives with high environmental and innovation cognition are more likely to perceive the potential benefits of policy incentives. They view green innovation as a competitive opportunity while avoiding resource waste caused by short-term decision-making. This study analyzes annual reports of listed companies, measuring executive cognition by counting the frequency of environmental and innovation-related keywords. Table 5 columns (1) and (2) show that the policy dummy variable coefficient is significantly positive, indicating that the synergistic effect of dual pilot policies significantly enhances executives' environmental and innovation cognition. This, in turn, incentivizes enterprises to pursue green innovation, achieving a win-win outcome of economic benefits and environmental responsibility.

5.2. R&D Investment Driving Pathway

R&D investment serves as the core support for corporate innovation. This study measures R&D intensity using the ratio of R&D expenditure to total assets. The results in Column (3) of Table 5 reveal that the synergistic effect of the dual pilot policies significantly increases corporate R&D intensity. The underlying logic is as follows: the Intellectual Property Demonstration City policy enhances corporate R&D confidence and stimulates investment willingness by strengthening intellectual property protection; the Low-Carbon City policy guides corporate resources toward green technology R&D. Together, they form a synergistic “incentive + constraint” force that accelerates the transformation of green innovation outcomes and drives corporate green transition.

5.3. Environmental Optimization-Driven Pathway

Regional disparities in intellectual property protection intensity directly influence corporate policy responses and innovation decisions. Drawing on Shen Guobing et al. (2019)[错误!未找到引用源。], this study constructs a quasi-explicit comparative advantage index based on the number of concluded intellectual property trials in city-level judicial case databases (from Peking University Law Database) combined with city GDP to measure regional IP protection intensity.

Table 5: Mechanism Test Results

	(1)	(2)	(3)	(4)
	Executive Innovation Awareness	Executive Environmental Awareness	R&D Intensity	Rule of Law Environment
did	1.6670*	0.2333*	0.0012*	0.1881***
	(0.9523)	(0.1340)	(0.0007)	(0.0210)
cons	-111.2599***	-1.1153	0.0830***	0.1118
	(16.1749)	(2.0279)	(0.0109)	(0.3814)
Control variables	Yes	Yes	Yes	Yes
Fixed effects	Yes	Yes	Yes	Yes
Sample	32641	29183	27537	30744
R2	0.748	0.609	0.804	0.515

6. Research Findings and Policy Implications

This study examines the impact of dual pilot policies—intellectual property demonstration cities and low-carbon cities—on corporate green technological innovation using a progressive difference-in-differences model with Shanghai and Shenzhen A-share listed companies from

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2007 to 2022 as the sample. Key findings are as follows: First, the synergistic effect of dual pilot policies significantly enhances corporate green technological innovation, with a more pronounced promotion effect on substantive green innovation. Second, this synergistic effect operates through three pathways: strengthening executives' environmental and innovation awareness, increasing corporate R&D intensity, and improving the regional legal environment. Third, overlaying the IP demonstration city pilot on the low-carbon city pilot more effectively stimulates corporate green innovation vitality.

Based on these findings, the following policy recommendations are proposed:

First, deepen policy coordination and integration. On one hand, strengthen interdepartmental communication and coordination to establish a unified policy framework and guidance documents, clarifying objectives and pathways while enhancing the synergy between intellectual property protection and environmental regulations to provide robust safeguards for corporate green innovation. On the other hand, expand the scope and intensity of intellectual property protection, focusing on policy synergy and implementation sequencing. First, create an atmosphere conducive to pollution reduction and carbon emission cuts through environmental regulations, then incentivize the commercialization of innovative outcomes via intellectual property protection. This policy “combination punch” will propel enterprises toward sustainable development.

Second, strengthen policy transmission pathways. Conduct training for executives on environmental protection and innovation awareness to promote the adoption of green innovation strategies. Reduce the costs and risks of green R&D for enterprises through measures such as fiscal subsidies and tax incentives, thereby boosting enthusiasm for R&D investment. Intensify intellectual property enforcement and optimize the legal environment to provide stable expectations for enterprise innovation, ensuring the full realization of synergistic effects from the dual pilot policies.

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